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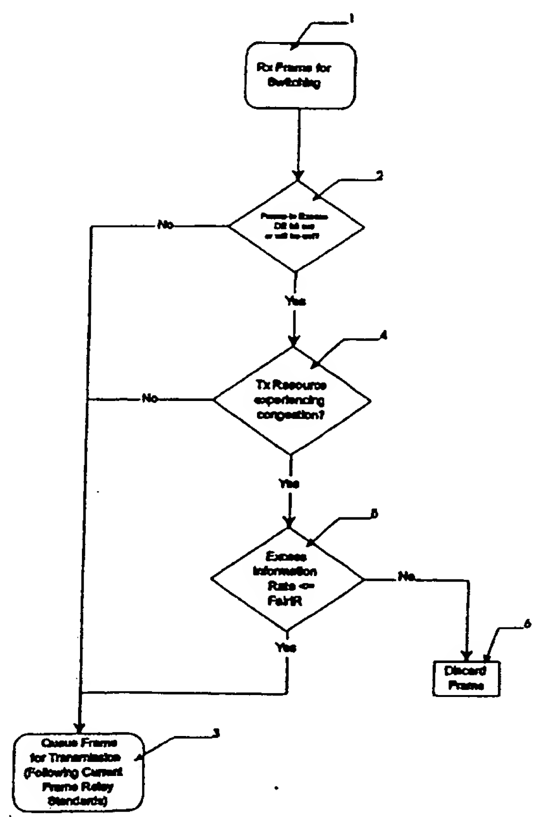
(54) Title: FAIR ALLOCATION OF EXCESS RESOURCES IN A COMMUNICATIONS SYSTEM

(57) Abstract

In a communications system, a method is described for controlling the excess usage of a finite resource through which information flows by a plurality of sources having an "excess" state. For each source a determination is made as to whether the source is in the excess state. If the excess information rate is less than a predetermined fair information rate, the information is passed to the resource. If the excess information rate is greater than the fair information rate, the information is discarded.



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FAIR ALLOCATION OF EXCESS RESOURCES IN A COMMUNICATIONS SYSTEM

This invention relates to a method of fairly controlling the excess usage of a finite resource, for example the usage of available bandwidth by permanent virtual circuits in frame relay networks.

In frame relay networks, permanent virtual circuits are set up through the network and frames are routed at each node in accordance with a virtual circuit id carried in the packet header. Available bandwidth is of course determined by the physical links and as a result congestion can occur in the network. When this happens frame relay may discard packets, which then must be re-transmitted.

Existing frame relay networks (based upon current frame relay standards) have a problem with regards to the way in which spare/free bandwidth is allocated. Virtual circuits competing for excess bandwidth are not subject to fairness. Frames received by the switching mechanism are switched out to an outgoing transmit queue. If the transmit queue is congested (i.e. virtual circuits on that piece of bandwidth are transmitting more than the resource can handle) then the number of frames in the transmit queue will increase, potentially eventually overflowing. Essentially, the virtual circuit transmitting the most frames will get to consume the most bandwidth and the most transmit and buffering resources.

Current technologies in this area rely upon the Committed Information Rate and congestion procedures defined in the ANSI specifications. These procedures allow the user devices in a network to be policed to a committed information Rate (CIR), but burst up to an excess information rate (EIR). Excess burst traffic is

marked as excess in frame relay by setting a DE (discard eligible) bit. DE frames are discarded in preference to non DE frames.

Other situations arise where the 'excess' usage of any resource by competing users needs to be controlled.

An object of the invention is to provide a method of fairly controlling the excess usage of a finite resource.

According to the present invention there is provided a method of controlling, in a communications system, the excess usage of a finite resource through which traffic flows by a plurality of information sources having a committed information rate and an excess information rate, characterized in that it comprises, for each source, carrying out the steps of determining whether traffic from said source is in the excess condition; determining whether the finite resource is experiencing congestion; if the result of the determination in steps a and b is positive, determining whether the excess information rate is less than a predetermined fair information rate; and if the excess information rate is less than said fair information rate, passing incoming traffic to the resource, and if the current information rate is greater than said fair information rate, discarding the incoming traffic.

In a preferred embodiment, the method of controlling the "fair " excess information rate is based upon the "leaky bucket" approach, although other bandwidth admissions procedures can be employed. This makes the allocation of excess resources 'fair' between competing virtual circuits. For example, in the case of a frame relay network, each virtual circuit runs its own instance of the described procedure.

The invention will now be described in more detail, by way of example only, with reference to the accompanying drawings, in which:-

Figure 1 is a flow chart illustrating the method in accordance with the invention;

Figure 2 is a diagram illustrating an application of the method; and

Figure 3 illustrates a "leaky bucket" implementation of the invention.

Referring now to Fig. 1, this shows an approach to the problem of fair resource allocation in a frame relay network.

In Figure 1, an incoming frame Rx 1 in a frame relay network is passed to decision unit 2, which determines whether the frame is in an excess condition indicated either by the DE bit being set, or by conventional frame relay information rate procedures setting the DE bit. If the frame is not in excess, it is passed to frame queue 3 for transmission over the permanent virtual channel using current frame relay standards in a conventional manner. If the answer is yes, the frame is passed to decision unit 4, which determines whether the transmission resource is experiencing congestion. If no congestion is being experienced, the frame is passed to output queue 3; if congestion is being experienced the frame is passed to decision unit 5. This determines whether the excess information rate is less than the Fair information rate, FairIR. If the answer is yes, the frame passed to output queue 3; if no the frame is passed to discard unit 6.

A Fair Burst (Bf) is defined as the number of bits in the outgoing resource (queue) that may be consumed by a virtual circuit within a time interval T. This value

is negotiated on a per virtual circuit basis at call set-up time. The sum of the Bf for all the permanent virtual channels on the that resource cannot normally be more than the total size of the resource. (e.g. Sum of all Bf <= txQueue Size in bits)

The FairIR (Fiar Information rate), which is the information rate allowed to 'leak' into the congested resource, is defined as Bf/ΔT, where ΔT is the Time period over which the rate is measured. ΔT is implementation dependent and usually small.

The measurement of the onset of congestion or the level of resource congestion is implementation dependent. For example, this can be achieved by monitoring the utilization of a resource and raising a congestion alarm if the utilization exceeds a predetermined threshold.

Figure 2 shows a specific embodiment of the invention comprising switches 14, 15 and physical links 13, 16. Virtual circuits 10, 11, 12 compete for available bandwidth in outbound physical link 16 from switch 15. Frames being switched onto physical link 16 are passed to transmit queue 3 for transmission on outbound physical link 16, which in accordance with the invention can be guaranteed to transmit some DE frames (the amount can be commissioned at call set-up based upon the PVCs Bf value) while the congested bandwidth resource is congested.

In the Figure 2, virtual channels are multiplexed onto a single physical link 16 having a predetermined bandwidth. Because of the nature of frame relay, PVC 10, PVC 11, and PVC 12 can send more data than the physical link 16 can handle.

In switch 15 the Tx bandwidth pipe 16 is assumed to be congested because PVC 10, PVC 11, and PVC 12 are

competing for finite bandwidth resources that are near depletion. In a traditional frame relay network, all three PVCs could burst beyond the negotiated Bc (burst capacity) and have their DE bits set on all excess frames. The PVC sending the most frames would get preference and could 'starve' the other PVCs from getting any DE frames through. Traditional networks are usually based upon a first come, first served model.

By applying the method described above frames received on PVC 10, PVC 11 and PVC 12 at Switch 15, all three permanent virtual channels can send DE frames on the congested resource, based upon Bf value for each PVC.

Figure 3 shows a "leaky bucket" implementation of the invention, which makes use of a sliding window approach and is carried out on a per call basis. First, on call set up, the Fair Burst is set to Bf, which is dependent on systems resources, ΔT is initialized, and a timer is started. When the ΔT timer expires, the fair burst is set to the [Fair Burst + (FairIR*ΔT)] or Bf, whichever is less and the ΔT timer restarted.

Simultaneously, the received frames are monitored to determine whether the DE bit is set, i.e. the frame is in excess. If not, the frame is passed to the transmit queue. If yes, the circuit determines whether the transmit resource is congested. If not, the frame is passed to the transmit queue. If yes, the circuit then determines whether the number of bits in the frame is less than the current fair burst. If the answer is no, the frame is discarded.

If yes the current fair burst is set to the old fair burst - number of bits in the frame and the frame passed to the transmit queue.

The circuit thus operates on the credit principle. Each time the timer is re-initialized, the "credit" fair burst rate for the channel is reset. This credit is then gradually used up as excess frames are transmitted until the timer expires, when the cycle repeats.

The invention thus allows PVCs 10, 11, 12 to have fair access to the physical link 16.

Claims:

1. A method of controlling, in a communications system, the excess usage of a finite resource through which traffic flows by a plurality of information sources having a committed information rate and an excess information rate, characterized in that it comprises, for each source, carrying out the steps of:

a) determining whether traffic from said source is in the excess condition;

b) determining whether the finite resource is experiencing congestion;

c) if the result of the determination in steps a and b is positive, determining whether the excess information rate is less than a predetermined fair information rate; and

d) if the excess information rate is less than said fair information rate, passing incoming traffic to the resource, and if the current information rate is greater than said fair information rate, discarding the incoming traffic.

2. A method as claimed in claim 1, characterized in the communications system is a frame relay network, said finite resource comprises available bandwidth on an outbound physical link from a switch in said network, and step a comprises determining whether a received frame for transmission on said outbound link is in an excess condition.

3. A method as claimed in claim 2, characterized in that step a comprises determining whether a discard eligibility bit of a received frame is set.

4. A method as claimed in claim 2, characterized in that the non-discarded traffic is passed to a transmit queue in the resource.

5. A method as claimed in claim 3, characterized in that the fair information rate is defined as the number of bits (Bf) in an outgoing resource queue that can be consumed by a virtual circuit within a predetermined time interval divided by an incremental time period over which the information rate is measured, where the sum of the Bf for all channels is less than or equal to the number of bits in the transmit queue of the resource.

6. A method as claimed in claim 1, characterized in that allocation of the resource is carried out using a leaky bucket procedure.

7. A method as claimed in claim 1, characterized in that upon initiation of a call, a predetermined fair burst value (Bf) is set and a timer started, and if both the result of the determination in steps a and b is positive and the number of bits in the frame is less than the fair burst value (Bf), the fair burst value Bf is reset to the old fair burst value less the number of bits in the frame, otherwise the frame is discarded.

8. A method as claimed in claim 1, characterized in that on expiration of the timer after a predetermined period of time, the fair burst value Bf is reset so to be the lesser of the current fair burst value plus the fair information rate multiplied by said time period, and the current fair burst value.

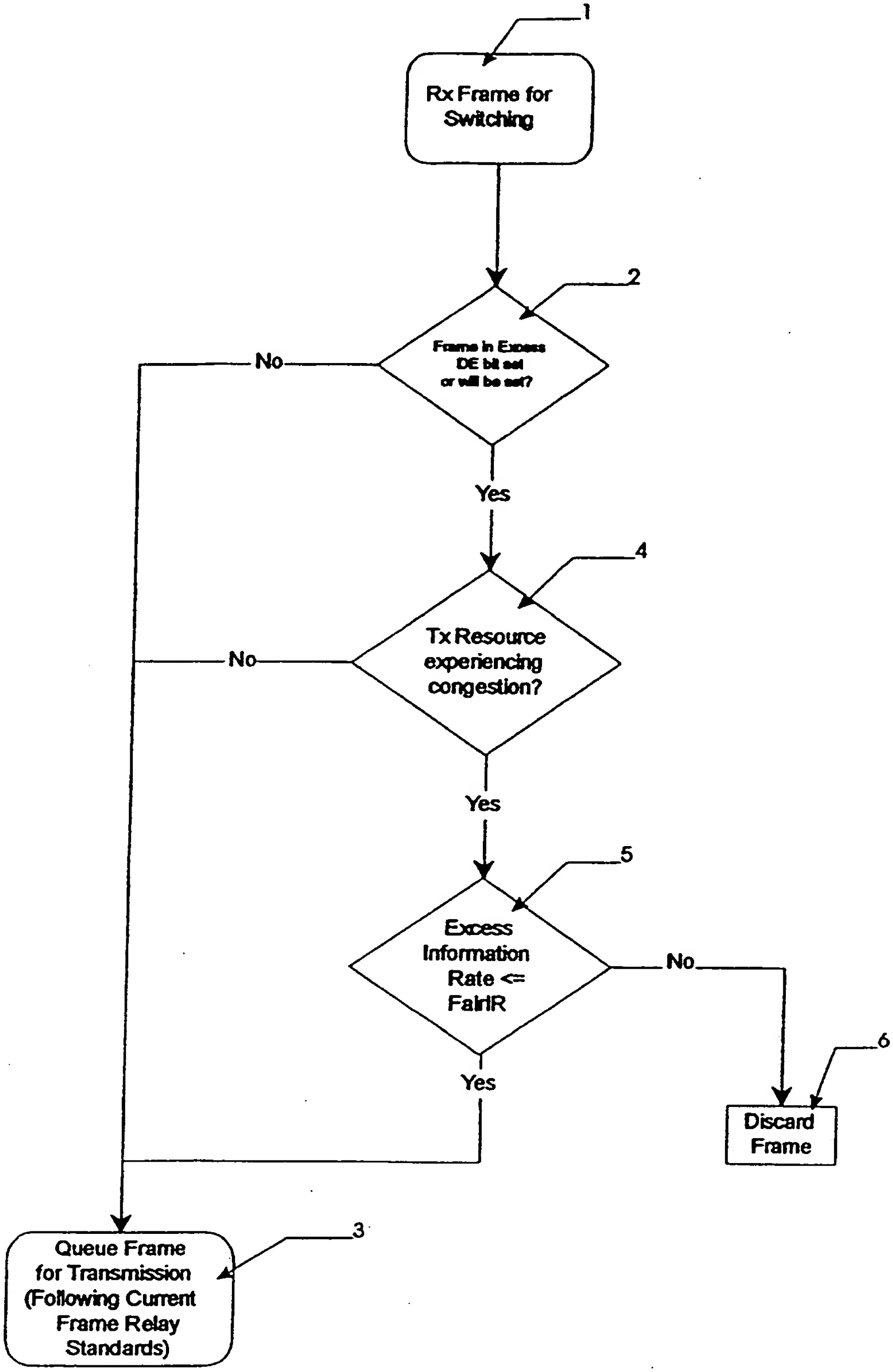
1
Rx Frame for Switching
2
Frame in Excess DE bit set or will be set?
No
Yes
4
Tx Resource experiencing congestion?
No
Yes
5
Excess Information Rate <= FairIR
No
Yes
6
Discard Frame
3
Queue Frame for Transmission (Following Current Frame Relay Standards)

Fig. 1

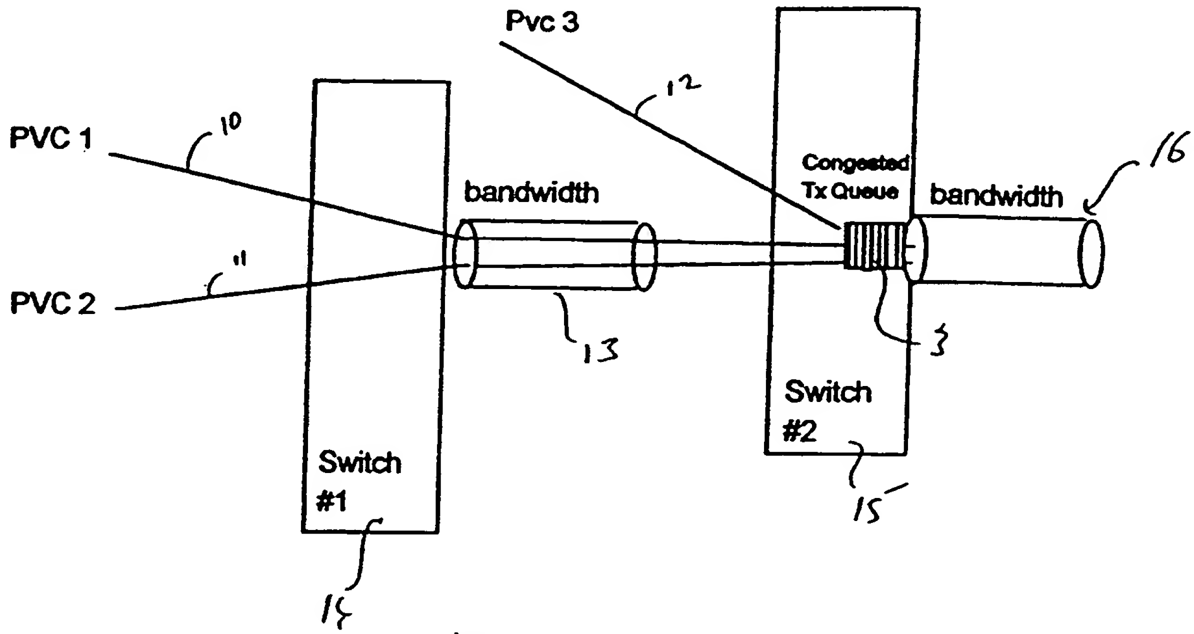
Pvc 3
12
PVC 1
10
PVC 2
11
bandwidth
13
Congested
Tx Queue
bandwidth
16
3
Switch
#2
15
Switch
#1
14

Fig. 2

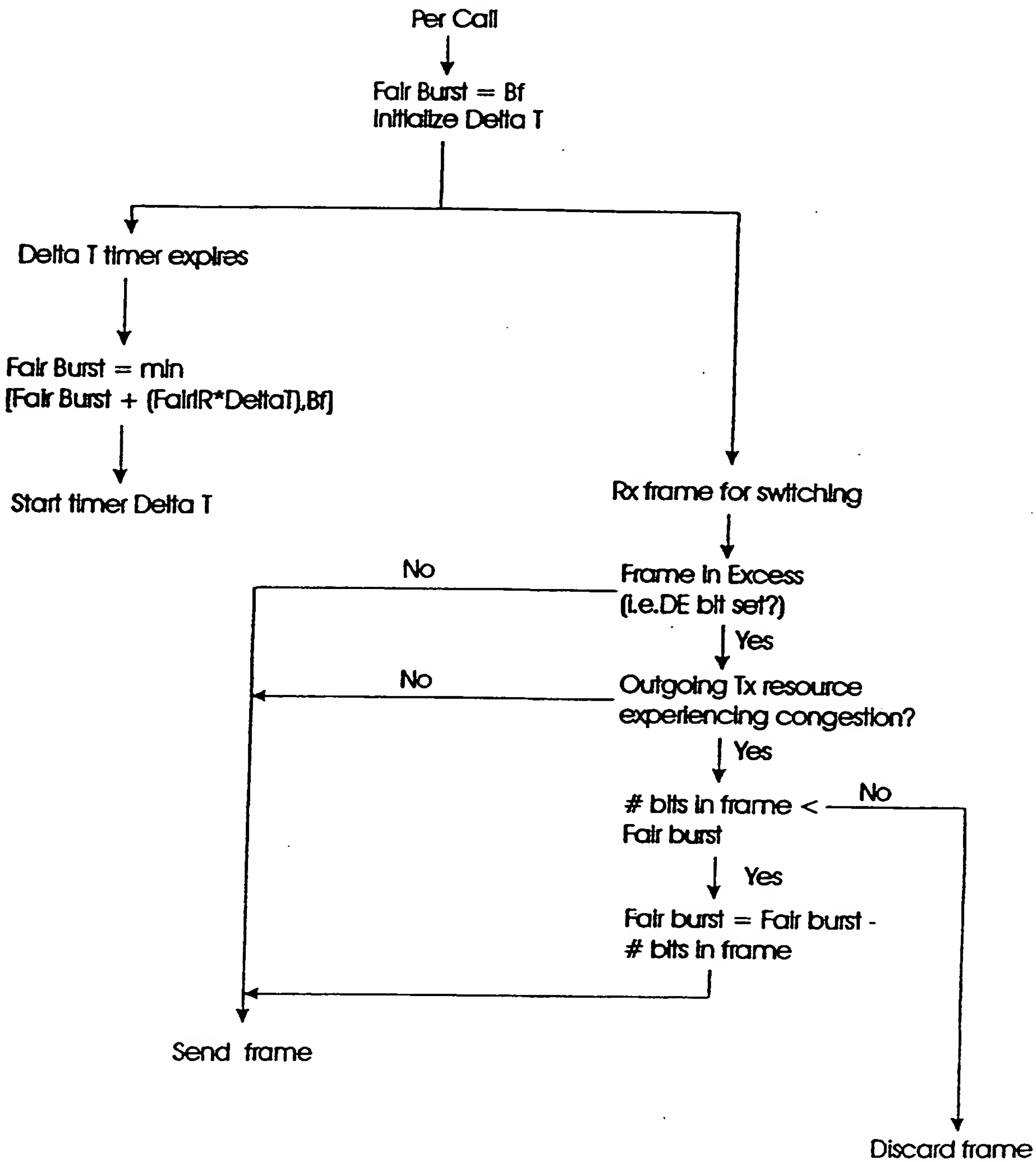
Per Call
Fair Burst = Bf
Initialize Delta T
Delta T timer expires
Fair Burst = min
[Fair Burst + (FairR*DeltaT),Bf]
Start timer Delta T
Rx frame for switching
Frame in Excess
(i.e.DE bit set?)
No
Yes
Outgoing Tx resource
experiencing congestion?
No
Yes
bits in frame <
Fair burst
No
Yes
Fair burst = Fair burst -
bits in frame
Send frame
Discard frame

Fig. 3

INTERNATIONAL SEARCH REPORT

Inte· ·ional Application No
PC↑/CA 95/00705

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04L12/56

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CONFERENCE ON COMPUTERS AND COMMUNICATIONS, March 1991 USA, pages 539-545, XP 000299084 D.B. GROSSMAN 'An overview of frame relay technology'	1-4,6
A	see paragraph 3.1	5,7,8

X	PACIFIC TELECOMMUNICATIONS CONFERENCE, vol. 1, January 1993 USA, pages 376-392, XP 000565982 K.S.R. MOHAN 'Enterprise networking using Frame Relay' see page 383, right column, line 27 - page 384, right column, line 41	1-4

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[X] Further documents are listed in the continuation of box C.

[ ] Patent family members are listed in annex.

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1

Date of the actual completion of the international search	Date of mailing of the international search report
25 March 1996	12.04.96
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Perez Perez, J

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	INTERNATIONAL TELETRAFFIC CONGRESS, June 1991 NL, pages 153-159, XP 000303023 B. DOSHI ET AL. 'Memory, bandwidth, processing and fairness considerations in real time congestion controls for broaband networks' see paragraph 5.2.2 -----	5,7,8

1